A REVISED CLASSIFICATION OF THE SPIRE-BEARING BRACHIOPODA.

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In the March number of the American Geologist for 1893, the writer published a paper entitled "A Classification of the Brachiopoda." Several works on the spire-bearing brachiopods have since appeared,* which greatly increase the knowledge of the suborder *Helicopegmata*, and suggest a more natural classification than was then possible. Therefore the following revised classification is offered:

Family Characters. Three types of brachidial structure of family importance have been observed which will serve to characterize the three families into which the suborder *Helicopegmata* is here divided. These structures are based on the position of the primary lamellæ with reference to the spirals and to the manner in which they join with the crura. These characters are as follows:

1. In the earliest and most primitive forms, the *Atrypidæ*, the primary lamellæ are directly continuous with the crura, diverge widely and have the spirals between them.

2. In the *Spiriferidæ*, the primary lamellæ are also directly continuous with the crura, but lie between the spirals, thus being the reverse of the *Atrypidæ*.

3. In the *Athyridæ* the primary lamellæ differ in direction from those in the other families in being more or less sharply recurved dorsally near their junction with the crura.

Subfamily characters. The nature and complexity of the loop which joins the spirals is the most important character for subfamily differentiation. There are five types of loops, the greatest variety occurring in the *Athyridæ*. Two of these are restricted, being common to the *Atrypidæ* and *Spiriferidæ*, while the three pertaining to the *Athyridæ* are specializations

* James Hall, assisted by John M. Clarke. An Introduction to the Study of the Genera of the Palæozoic Brachiopoda, Pal. New York, vol. viii, pt. ii, fascicle i, pp. 1-176, July, 1893.

A. Bittner. Brachiopoden der Alpinen Trias, Abh. d. k. k. geol. Reichs., Bd. xiv, pp. 1-325, Taf. 1-41, 1890; Nachtrag I, Ibid., Bd. xvii, Heft 2, pp. 1-40, Taf. 1-4, 1892; Neue Koninckiniden des Alpinen Lias, Jahrb. d. k. k. geol. Reichs., Bd. 43, Heft 1, pp. 133-144, Taf. iv, 1893.

C. E. Beecher and C. Schuchert. Development of the brachial supports in Dielasma and Zygospira, Proc. Biol. Soc. Washington, vol. viii, pp. 71-82, 1893.

of the primitive loop of the two other families. These types may be defined as follows:

1. Primitive loop a simple band, variously situated, becoming in the higher forms more or less V-shaped. Present in *Zygospirinæ*, *Dayinæ*, *Suessiinæ*, and *Uncitinæ*.

2. Loop a simple band in young or immature stages, but at maturity more or less medially absorbed, and eventually only represented by two short prongs, one attached to each primary lamella. Characteristic of *Atrypinæ* and *Trigonotretinæ*.

3. Loop V-shaped, with its apex more or less drawn out into a simple or terminally modified extension, which is but rarely bifurcated. Present in *Anoplothecinæ*, *Rhynchospirinæ* and *Hindellinæ*.

4. The loop process always present with the distal end bifurcated. The branches are of variable lengths and either terminate freely between the first and second volutions of the spirals, or may continue with these to their outer ends. Present in *Athyrinæ*, *Diplospirinæ*, and *Koninckininæ*.

5. The branches of the process remain between the spirals, recurve and join near their origin, thus resembling the handles of a pair of scissors. Present in *Meristellinæ*.

The ontogeny of *Zygospira* indicates that the *Helicopegmata* was the last to appear and had its origin in the *Ancylobrachia* or terebratuloids. The suborder first manifests itself as far as known in the lower portion of the Lower Silurian. It attains its climax of differentiation in the Devonian, with another outburst of specialization in the Triassic chiefly among the double-spired athyroids, while there is rapid decline and final extinction in the Jurassic. Of the eight suborders into which the class Brachiopoda is now divided, only one, the *Trullacea*, or pentameroids, became extinct before the *Helicopegmata*. These two suborders are the only extinct ones of the class. The other six groups still have living representatives, are widely distributed, and are represented by about one hundred and thirty species.

Suborder **HELICOPEGMATA**, Waagen 1883.

Spiriferacea, Waagen 1883.

Brachiopods in which the two spirally enrolled brachia have internal calcified supports which are more or less completely

joined by a simple or variously modified and complicated calcareous loop.

I. Family **ATRYPIDÆ**, Dall 1887.

Crura directly continuous with the primary lamellæ which diverge widely and have the spirals between them. Loop simple, complete or incomplete; shell structure impunctate.

A. Subfamily Zygospirinæ, Waagen 1883.

Anazygidæ, Davidson 1884.

Loop a single connecting band either posteriorly or anteriorly directed. Spirals usually introverted, with their apices toward the median dorsal region.

Zygospira, Hall 1862.
- Stenocisma, Hall 1874 (not Conrad 1839; Hall 1867).
- Anazyga, Davidson 1882.
- Orthonomæa, Hall 1858.
- Hallina, Winchell and Schuchert 1892.
- Protozyga, Hall and Clarke 1893.

Catazyga, H. and C. 1893.

Atrypinæ. H. and C. 1893.

Glassia, Davidson, 1882.

? Clintonella, H. and C. 1893.

B. Subfamily Dayinæ, Waagen 1883.

Loop drawn out posteriorly into a simple short process. Spirals laterally directed.

Dayia, Davidson 1882.

A[1]. Subfamily Atrypinæ, Waagen 1883.

Loop situated extremely posterior, complete in young stages, but at maturity medially absorbed. Spirals dorsomedially directed.

Atrypa, Dalman 1828.
- Cleiothyris, Phillips 1841 (not King 1830).
- Spirigerina, d'Orbigny 1847.

Grünewaldtia, Tschernyschew 1885.

? Karpinskya, Tsch. 1885.

II. Family **SPIRIFERIDÆ**, King 1846 (emend Davidson).

Martiniinæ and Reticulariinæ, Waagen 1883; Spiriferinidæ, Davidson 1884.

Primary lamellæ directly continuous with the crura and situated between the laterally directed spirals, except in *Cyclospira* where they are somewhat introverted. Loop simple, complete or incomplete.

A. Subfamily Suessiinæ, Waagen 1883.

Loop a continuous, more or less V-shaped band.

Cyrtina, Davidson 1858.
Thecocyrtella, Bittner 1892.
Cyrtotheca, Bittner 1890 (not Salter).
Spiriferina, d'Orbigny 1847.
Suessia, Deslongchamps 1854.

Subfamily Uncitinæ, Waagen 1883.

Loop as in *Suessiinæ*. Just within the posterior margin of the dorsal valve are pouch-like plates. Deltidial plates united, deeply concave. Subfamily anomalous.

Uncites, Defrance 1825.
? Uncinella, Waagen 1883.

B. Subfamily Trigonotretinæ, Schuchert 1893.

Delthyrinæ (part), Waagen 1883.

Loop at maturity largely absorbed medially, being then represented by two processes, one attached to each primary lamella.

? Cyclospira, Hall and Clarke 1893.
Spirifer, Sowerby 1815.
Choristites, Fischer, de Wald. 1815.
Trigonotreta, Koenig 1825; Meek and Hayden 1864.
Spiriferus, Blainville 1827.
Spirifera, J. de C. Sowerby 1835.
Brachythyris, McCoy 1844.
Fusella, McCoy 1844.
Hysterolithus, Quenstedt 1871.
Cyrtia, Dalman 1828.
Syringothyris; Winchell 1863.
Spirifer, Meek and Hayden 1864.
Delthyris, Dalman 1828.
Martinia, Waagen 1883.
Martiniopsis, Waagen 1883.
Mentzelia, Quenstedt 1871.
Ambocœlia, Hall 1860.
Reticularia, McCoy 1844.
Verneuilia, H. and C. 1893.
? Metaplasia, H. and C. 1893.

III. Family **ATHYRIDÆ**, Phillips 1841.

Nucleospiridæ, Davidson 1882; Koninckinidæ, Davidson 1853.

Primary lamellæ situated between the spirals, and sharply recurved dorsally at their junction with the crura. Spirals more or less laterally directed. Loop complete, V-shaped, the apex being always drawn out into a simple, bifurcated, or otherwise terminally modified, process.

A. Subfamily Rhynchospirinæ,* n. subfam.

Retziinæ, Waagen 1883.

The single process of the loop commonly sharply recurved,

*Since Retzia does not express the characters of this subfamily as well as Rhynchospira does, Waagen's term Retziinæ is here abandoned.

but sometimes bifurcated. Shells plicate: structure distinctly punctate.

Homœospira, Hall and Clarke 1893.
Rhynchospira, Hall 1859.
Ptychospira, H. and C. 1893.
Eumetria, Hall 1864.
Trematospira, Hall 1857.
Parazyga, H. and C. 1893.
Acambona, White 1862.
Hustedia, H. and C. 1893.
Retzia, King 1850.
Trigeria, Bayle 1878.

B. Subfamily Hindellinæ, n. subfam.

Loop with a single process which may be simple, or may articulate in a ventral septal socket, sometimes (rarely) being sharply recurved terminally. Shells smooth, finely spinose, or plicate: structure impunctate.

Hindella, Davidson 1882.
Whitfieldella, H. and C. 1893.
Meristina, Davidson 1882 (not Hall 1867).
Nucleospira, Hall 1858.
Hyattella, H. and C. 1893.
Anoplotheca, Sandberger 1856.
Bifida, Davidson 1882.
Cœlospira, Hall 1863.
Leptocœlia, Hall 1857 and 1859
Vitulina, Hall 1860.
? Anabaia, Clarke 1893.

B¹. Subfamily Athyrinæ, Waagen 1883.

The single process of the loop with distal bifurcations which may or may not terminate between the first and second volutions of the spirals. Shells smooth, lamellose spinose, or with a few sharp, non-alternating plications: structure impunctate.

Meristina, Hall 1867.
Athyris, Davidson 1853 (not McCoy 1844).
Whitfieldia, Davidson 1882.
Glassina, Hall and Clarke 1893.
Athyris, McCoy 1844.
Spirigera, d'Orbigny 1847.
Euthyris, Quenstedt 1871.
Actinoconchus, McCoy 1844.
Cleiothyris, King 1850 (not Phillips, 1841).
Seminula, McCoy 1841.
Spirigerella, Waagen 1883.
Anomactinella, Bittner 1890.
Pomatospirella, Bittner 1892.
Amphitomella, Bittner 1890.
Plicigera, Bittner 1890.
Tetractinella, Bittner 1890.
Pentactinella, Bittner 1890.

B². Subfamily Diplospirinæ, n. subfam.

Bifurcations of the loop process very long, lying between the volutions of the spirals, and continuing with these to their outer ends. Sometimes there is an additional process on the

apex which articulates with the ventral valve. Shells smooth or plicate; structure impunctate.

Kayseria, Davidson 1882.
Diplospirella, Bittner 1890.
Euractinella, Bittner 1890.
Pexidella, Bittner 1890.
Anisactinella, Bittner 1890.

C. Subfamily Koninckininæ, Waagen 1883.

Amphiclininæ, Waagen 1883; Diplospidæ and Diplospiridæ, Munier-Chalmas, 1880.

Loop and spirals essentially as in *Diplospirinæ*. The spirals in *Koninckininæ*, however, are not laterally directed as in the former group, but point ventrally, which is due to the strophomenoid form of the shell. Cardinal areas more or less well developed. Shells smooth; structure impunctate.

Koninckina, Suess 1853.
Amphiclina, Laube 1865.
Koninckella, M.-Chalmas 1880.
Koninckodonta, Bittner 1893.
? Thecospira, Zugmeyer 1880.
? Amphiclinodonta, Bittner 1890.

Bª. Subfamily Meristellinæ, Waagen 1883.

The loop bifurcations do not enter the spirals, but recurve and join near their origin. Shells smooth; structure impunctate.

Meristella, Hall 1860.
Charionella, Billings 1861.
? Pentagonia, Cozzens 1846.
Goniocœlia, Hall 1861.
Dicamara, Hall and Clarke 1893.
Merista, Suess 1851.
Camarium, Hall 1859.
Dioristella, Bittner 1890.
? Camarospira, H. and C. 1893.

U. S. National Museum, December, 1893.

PHOSPHATE-BEARING ROCKS IN MIDDLE TENNESSEE.--PRELIMINARY NOTICE.

By J. M. Safford, State Geologist, Nashville.

Within the highland belt of country lying west of the meridian of Nashville, and between that and the Tennessee river, the phosphate-bearing beds associated with the Black Devonian shale are just now attracting attention on account of the prospect of finding certain parts of them rich enough in phosphate material to be of economic importance. There are